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think is quite indefensible. In this chapter Prof. Gaudry discusses the flints found by the Abbé Bourgeois in the Middle Miocene (Calcaires de Beauce) of Loir-et-Cher, concerning which opinions so differ. They are regarded as works of art by many archæologists, among whom are cited MM. de Vibraye, de Mortillet, de Quatrefages, Hamy, etc., and the figures given by Prof. Gaudry are certainly favorable to this view. The great antiquity of the horizon is opposed to the belief that they could be the work of human hands, for the Calcaires de Beauce represent a horizon not much above the Oregon beds of our White river formation. As Gaudry remarks, no species of Mammal of that period still exists; and he adds, "it is not probable that the cutters of those flints remained the same amid universal change." His concluding words are as follows: "If then it is to be shown that the flints of the Calcaire de Beauce, collected by the Abbé Bourgeois have been cut, the idea which presents itself most naturally to my mind is, that they were fashioned by the *Dryopithecus*."

As a popular and at the same time scientific exposition of the succession of Mammalian forms, as displayed by their structural details, this book has no rival. The author has been led, like most other thorough students, to adopt the doctrine of evolution, and some of his reasons are here clearly set forth. The work is distinguished for the excellence of its engravings and typography.

RYDER ON THE MECHANICAL GENESIS OF TOOTH FORMS.¹—In the several articles relating to this subject Mr. Ryder has made a valuable contribution to the doctrine of evolution. He adopts the classification of teeth proposed by Cope, and endeavors to explain by mechanical laws the succession or phylogeny of the various existing dental types pointed out by the same author. The application of mechanical theory to this question is ingenious, and results in some very probable hypotheses. First among these is the supposed effect of lateral pressure in flattening conical cones or cusps so that their section becomes semicircular or crescentic. Another is the probable crowding of tubercles on each other by impact transverse to their direction, producing plicate structure. His conclusions may be stated more in detail, and are as follows:

1st. That in *Carnivora* and *Omnivora* the jaws were simply opened and closed during mastication without lateral movement of the mandible or lower jaw, and that the earliest and most constant type of tooth accompanied this movement; that is, that the tubercles or cusps composing the teeth do not to any extent depart from the short-rooted type with conical tubercles, styled by odontologists bunodont. That the distance apart of the series of molars of opposite sides, of both upper and lower series, was

¹*On the Mechanical Genesis of Tooth Forms.* By JOHN A. RYDER. Proceedings of the Academy Natural Sciences, Philadelphia, 1878, p. 45. Further notes on do. Loc. cit., 1879, p. 47.

approximately alike; that is, that in closing the jaws the external or buccal cusps of the upper series were brought exactly upon a line with those of the lower, not over them, as is the case in all *Herbivora* and to some extent in man. This condition he has called isognathism.

2d. That in the *Herbivora* the jaws were opened and closed in mastication with extensive lateral movement of the mandible; and that the teeth were by this greatly modified in respect of their tubercular constitution, the tubercles being of the type known as crescentic, giving us the long-rooted selenodont type of tooth. That in these the width of the jaw, or the distance apart of the upper series of molars of opposite sides of the head, greatly exceeds the same measurement in the mandible, which results in the external or buccal cusps of the upper series closing over and external to the buccal cusps of the lower series. This condition he has styled anisognathism.

3d. That in some *Rodentia* and *Proboscidea* the mandibles were moved in a backward and forward, or antero-posterior direction, which he has termed the reciprocating movement, with which there was also a corresponding tubercular modification, which he calls trichecodont—three tubercles forming transverse ridges, frequently obsolete, or greatly flattened transverse lamellæ, composed of elongated and united tubercles soldered together by a thick cementum layer. (Elephas). Isognathism is usually a characteristic of this subdivision.

4th. That in a subdivision including a part of *Rodentia* and *Proboscidea* (mastodon), the movement of the mandible was both reciprocating and lateral, with a still more complex type of dentition as a result, which he has styled ptychodont—enamel fluted and folded upon itself longitudinally and transversely. These jaws are usually anisognathous.

These observations, based upon investigations made not only upon the skulls but also upon the living animals, afford, he thinks, the key whereby to correctly interpret the morphological history of the teeth of the higher groups, especially when brought to bear on the interpretation of the teeth of the great number of herbivorous remains which the rocks have yielded in recent times as intermediate or antecedent forms.

The number of kinds of excursions made by the mandibular rami is limited by structural impediments, since a bar fixed at one end and free at the other, to which the mandible may be compared, is capable of but a few distinct movements. We find these to be essentially those mentioned in the definition of the four groups; few others are possible or conceivable. The first movement is the vibratory one in a vertical plane; the second is the vibratory movement in both the horizontal and vertical planes; the third is the vibration of the rami in an approximately horizontal plane, neither lateral nor vertical, but an antero-posterior

or reciprocating movement, parallel to the medial axis or line; the fourth is that which combines to a great extent the second and third. It is also to be observed that the lines described in most cases are not straight, but only approximately so, they being more or less curvilinear. With these four distinct types of mandibular movement there are as many distinct types of tooth-modifications, to which almost all the forms of teeth of *Mammalia* yet known may be referred. The bunodont type is that characteristic of group 1, and in which the tubercles have not been modified, because there have been no movements of a proper kind to produce the modifications in the enamel foldings as observed in the longitudinally or the transversely folded enamel crowns of the lophodonts (ridge or hill tooth). To this foregoing group 1 belong also all the haplodont type (simplest form) as observed in the toothed whales.

According to the doctrine of mechanical dental differentiation, the foldings of the enamel in the teeth of groups 2, 3 and 4, whether they be longitudinal or transverse, are due either to the lateral or reciprocating movement of the jaws. The sub-group, selenodonts—so called in consequence of the crescent-shaped foldings of the enamel of which the deer is a familiar example—is perhaps the most striking illustration of all. The characteristic crescent-shaped tubercles, the author thinks, have probably been evolved by a very slow process of flattening and bending outwards or inwards of the cornu of the tubercles, due to the strains exerted in masticating the tough woody food. The movement in this case being constantly in one direction, makes it still more probable that such has been the history of the process.

The incisors of many animals having been lost or hypertrophied either from the assumptions of their functions by other parts, as the lips, tongue or trunk, or by substitution of another function, as in the case of the tusks of the Proboscidiæ, it would seem that mechanical resistance has much to do with their special development, as is also seen in Rodents.

A summary of the foregoing views the author has stated as follows:

"1. That the earliest and simplest type of mammalian jaw-movement was that in which the mouth was simply opened and closed, without mandibular excursion, and co-existent with the simple haplodont or bunodont molar.

"2. That the development of the various kinds of excursive mandibular movement has apparently been progressive.

"3. That as the excursive movements have increased in complexity, there has been an apparent increase in the complexity of the enamel foldings, ridges and crests.

"4. From the fact that the foldings, etc., have apparently been modified in conformity to the ways in which the force used in mastication was exerted, it is concluded that the various modes

of crest and tubercular modification are related as effects to the diverse modes of mandibular movement.

"5. It is apparent from the facts presented throughout the context that the mandibular articulations, and correlatively the skull have probably been modified in shape by the movements made by the jaws and the forces exerted in executing them.

"6. From the fact that the incisor teeth are partially or entirely absent, or relegated to another function, in forms which have long prehensile tongues, mobile, prehensile lip or proboscides, it is held to be probable that such disappearance of the incisive dental elements is due to the assumption of their function by the prehensile organs indicated."

The bearing of these conclusions on the general doctrine of evolution is clear enough. The author of the papers reviewed has endeavored, and we think with much success, to solve in this field, the real question in hand, which is not so much the "survival of the fittest" (Darwinism), as the *origin of the fittest*. In so doing he has found it necessary to avail himself of the hypothesis of "acceleration and retardation," and of "use and effort;" views which have often found advocacy in the pages of this journal. We think that Mr. Ryder has supplied an important link in the chain of evidence which connects motion¹ as a cause, with structure as an effect, and we shall anticipate for him future success in this fertile field of inquiry.

RECENT BOOKS AND PAMPHLETS.—Boletín de la Sociedad de Geografía y Estadística de la República Mexicana. Tercera época, Tomo IV, correspondiente al año de 1878. Nos. 4 and 5. Mexico, 1879. From the society.

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¹ See this journal, January, 1878.